

VENIPUNCTURE AND INTRAVENOUS INFUSION ACCESS  
DURING ZERO-GRAVITY FLIGHT

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DURING ZERO-GRAVITY FLIGHT

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JUSTIFICATION:

This experiment will establish the difficulty associated with securing and intravenous (IV) catheter in place in zero-g flight and the techniques applicable in training the Crew Medical Officer (CMO) for Space Station, as well as aiding in the selection of appropriate hardware and supplies for the Health Maintenance Facility (HMF).

OBJECTIVES:

- To determine the difficulties associated with venipuncture in a zero-g environment.
- To evaluate the various methods of securing an IV catheter and attached tubing for infusion with regard to the unique environment.
- To evaluate the various materials available for securing an intravenous catheter in place.
- To evaluate the fluid therapy administration system when functioning in a complete system.

## INFLIGHT TEST PROCEDURES (CHECKLIST FORMAT):

### Approach:

Set up of hardware including priming of the IV infusion set and infusion pump, sterile preparation of the selected infusion site, venipuncture and methods and materials for securing the IV catheter in place.

#### 1. Hardware Deployment:

- set up of IV fluid and administration set
- set up of trash containers (sharp, wet and dry) restraint of patient
- restraint of CMO
- priming of administering set
- priming of infusion pump with set and fluid

#### 2. Preparation of Insertion Site:

- selection of appropriate peripheral vein for access
- evaluation of appropriate method for restraint of extremity for insertion
- preparation of associated insertion supplies
- aseptic preparation of the site

#### 3. Insertion of the Catheter

- venipuncture
- evaluation of appropriate method for CMO restraint for insertion of catheter
- attachment of the administration set
- infusion of fluids

#### 4. Securing the Catheter

- selection of appropriate method for securing catheter
- selection of appropriate method for securing tubing

#### 5. Evaluation of system function

- as a complete system from pump to patient

**6. Discontinuation of Infusion**

- the infusion will be discontinued and an appropriate dressing applied
- prior to landing
- restowing of equipment, supplies and trash

**PARABOLA REQUIREMENTS, NUMBER AND SEQUENCING:**

No special requirements for intervals and spacing between parabolas.

**Parabolas 1-10**

- Deploy and set up hardware and supplies
- Restraint patient
- Restaint CMO
- Priming of lines
- Evaluation of containment of supplies for access

**Parabolas 11-20**

- Preparation of insertion site and insertion supplies
- Insertion of catheter
- Connection to system
- Evaluation of restraint of CMO for insertion positioning

**Parabolas 21-30**

- Evaluation of placement and system function
- Securing of catheter by various methods
- Securing of tubing by various methods

**Parabolas 31-40**

- Repeat of any previous procedures which need further evaluation

**TEST SUPPORT REQUIREMENTS (GROUND AND FLIGHT):**

Space Required:	Full width of KC-135, and 10 feet of length
Load flight week:	One Mini Rack

Load flight day:        video camera  
                              carry on bag (ALS pack) containing medical  
                              supplies,  
                              IV fluids, attachments, and catheters  
                              IV pump  
                              ambulance stretcher

Power requirements:    110 VAC for IV pump backup capability

**DATA ACQUISITION:**

- In flight written checklist
- self report post flight
- videos

**MANIFEST:**    Debra T. Krupa-DK (KRUG)  
                      John Gosbee-JG (KRUG)  
                      Roger Billica-RB (KRUG)  
                      Perry Bechtle-PB (KRUG)  
                      Joey Boyce-JB (NASA)  
                      Stan Koszelac-SK (NASA)

**PHOTOGRAPHIC REQUIREMENTS:**

Non-dedicated still video photography

**PROJECTED RESULTS:**

The requirements of adaptation to microgravity may require some changes in technique for both venipuncture and securing in place an indwelling IV catheter and tubing. We expect to determine appropriate techniques for placement and securing them. We expect also to document the correct function of the IV fluid therapy system in a simulated clinical situation of zero gravity.

**STRUCTURAL LOAD ANALYSIS:** See HMF Mini-rack experiment (1-24-90)

**ELECTRICAL LOAD ANALYSIS:** See HMF Mini-rack experiment (1-24-90)

**HAZARD ANALYSIS/SAFETY:**

1. Potential Hazard: Loose items may float free from drawer or pack

Response: Only one item at a time will be deployed from the drawer or pack at a time. All items which are deployed will be restrained to the patient restraint. Items which become free incidentally will be retrieved by a designated experimenter before they float from the area.

2. Potential Hazard: Fluid could float free from insertion site

Response: One experiment will be designated to remain at insertion site with access to area to contain released fluids with gauze pads. The IV set will be flushed into a gauze pad to clear the line and prevent any fluid from being released into the environment.

3. Potential Hazard: Catheter has needle for insertion which could cause puncture wound to experimenter

Response: All catheters will be standard medical equipment which comply with medical and surgical safety standards. The catheter will be restrained in its packaging when not in use, and will be deployed by an experienced medical care provider who is trained in its use and has had years of experience of use with this instrument in an aviation environment. The used needle will be disposed of in a specified "sharps" container.

**INFLIGHT WORKSHEET KC 135 FLIGHT EVALUATION  
VENIPUNCTURE AND INTRAVENOUS INFUSION ACCESS DURING  
ZERO GRAVITY FLIGHT**

**PREFLIGHT:**

Load equipment onto KC 135 and secure

- video camera
- restraints for investigators
- waste disposal containers solid, wet, and sharp
- IMED pump
- IV section of ALS pack containing:
  - IV solution (ringer's lactate)
  - IV catheters x 4
  - fluid administration sets x 2
  - site prep
  - tape
  - 4 x 4
  - tourniquet
  - bandaid
- ambulance stretcher
- sterile gloves

Bungee cords were placed on the floor of the aircraft in the appropriate position for restraint of the CMO, the photographer, and assistants. Each person in the team reviewed the portions of the flight that they were responsible for, and a dry run through of the procedure occurred with each CMO. The restraints for the patient were reviewed and adjusted. Padding was placed within the litter for comfort of the patient.

The introductory video portion was recorded prior to take off after securing the equipment and supplies.

**BEFORE PARABOLAS BEGIN:**

**Deploy ALS pack and supplies, and secure to side of stretcher**

The ALS pack and IV pump were destowed and secured to the area right next to the stokes litter. They were secured into place with tie down straps

and rings. The ALS pack was opened and held in place with bungee cords.

**Secure patient to stretcher**

The patient (RB) chose not to remain within the litter during the set up procedures. He chose to wait until after the pump was set up before being secured within the litter. One last review was made of the placement of the restraint straps.

**Secure waste containers within easy access of CMO**

The waste container was placed along side of the mini-racks. An assistant will remain next to the CMO to manage trash. A large waste bag was taped to the side of the aircraft for wet trash.

**Secure CMO and assistants**

After a last check of placement of all equipment, the CMO and assistants gained their positions for the flight. The CMO (DK) was restrained by bungee cords over her heels, and had access to a waist restraint to the side of the litter if required. The camera operator was placed on the opposite side of the litter with similar restraints. Various restraint straps were placed to allow movement of the assistants around the experiment area.

**Recheck video placement**

The camera operator once again reviewed distance and placement to assure optimal recording of events.

**BETWEEN SETS OF PARABOLAS:**

**Dispose of waste materials**

There was some difficulty with the waste container chosen for the flight. It was made of large wire mesh, and did not contain many of the numerous small (2-5cm) items generated by this experiment. The pockets of the flight suit were often used for this purpose.

**Alter CMO and protocol as required**

- After successful insertion of the catheter by DK, PB was positioned to

attempt the second placement.

- Due to difficulty with purging the tubing, it was decided to use the same fluid bag and tubing on the second attempt.
- There were also changes in the sequencing of parabolas, and various procedures were completed in other parabolas than those scheduled. All procedures were completed.
- Due to the second patient becoming ill during the flight, RB was the patient for both insertions.
- There was a difficulty with the function of the IV pump during the second insertion attempt, and the set was not run on the pump for this insertion. The bag was placed in a pressure bag rather than on the pump.

#### KC-135 VENIPUNCTURE WORKSHEET:

Procedures were completed only within the microgravity portion of flight except where stated otherwise.

##### Parabolas 1-10

##### *Deploy Supplies*

DK accessed the ALS pack for the supplies for insertion. The IV fluid and administration set were removed. The IV pump was turned on and appropriate settings placed. The pump was set for administration of a 500cc bag of ringer's lactate at 125cc/hour. There were no difficulties with this procedure.

##### *IV administration set up and prime lines*

DK removed the fluid and the administration set from the storage bags. The bags were handed to the assistant for disposal. The tubing was then uncapped at the spike end, and the fluid bag insertion port uncovered. The cap covers were released to float free, as there was no method for containment of such small items. The tubing was then connected to the fluid bag with the clamp in place. During this attempt, the tubing, which is quite long, floated rather freely and followed the air currents of the aircraft. This could prove



to be a problem with certain procedures.

The line was opened to permit priming the administration line (IV tubing). This was more difficult than anticipated. It was very hard to squeeze the bag to force the fluid through the tubing. The purging of the tubing took 3 parabolas. The set was then placed within the pump and placed on standby for insertion.

The fluid bag was velcroed to the side of the pump, which worked very well. The tubing was allowed to float free until needed. (As it was connected to the pump, there was no danger of losing access to the tubing.)

At this point the patient (RB) secured himself within the litter.

#### Parabolas 11-20

##### *Preparation of site and insertion supplies*

The start kit was velcroed to the pump for ease of access to its contents. The tourniquet was removed and placed on RB's left arm the elbow. Strips of transpore tape were prepared, and placed on the pump for easy access after insertion. The site was prepped following standard medical protocols with a betadine swab and an alcohol swab. The catheter was removed from the package, and protective cover. These were handed to the assistant. A #18 gauge angiocath was used for the insertion.

##### *Insertion of catheter*

The catheter was placed by DK in a vein in the dorsal vein of the hand. There was rapid blood return into the catheter hub. DK held 2x2 of gauze in place in preparation for control of blood return, however this was not needed. The catheter was threaded into place over the needle with no difficulty. The insertion occurred on the first attempt.

##### *Connection to system*

The tourniquet was released and DK accessed the end of the tubing for connection to the catheter. DK placed her left thumb over the insertion site to hold pressure, and then removed the needle from the catheter with her right hand. The needle was placed (inserted) into the cloth of the litter for

containment and protection. The tubing was then connected by DK with her right hand onto the catheter. Upon securing the connection of the tubing and the catheter, a small amount of IV fluid was released onto RB's forearm which was absorbed by DK with the gauze.

#### *Activation of the system*

The catheter was taped into place with a preliminary strip of tape across the catheter. DK then activated the pump. The pump infused well at the set rate of 125 cc/hour, and no problems were noted.

#### *Securing of catheter and system*

The catheter and tubing were then secured into place by DK. Transpore tape was placed by DK following standard medical procedure. Betadine ointment was placed over the site and a bandaid for coverage. The tubing was secured to the forearm.

#### *Evaluation of the system*

RB then moved his arm through all axis of rotation and movement. He placed his arm in various positions relative to the pump, and no difficulty in function was noted. RB denied any pain or discomfort. The pump functioned properly through all movements and continued to administer fluid as programmed.

#### *Evaluation of restraint of CMO and patient*

The restraint of the CMO in a kneeling position beside the patient worked well. DK reported that one heel was placed within the bungee cord and one remained free. DK reported that with the sloped side of the stokes litter, she was able to additionally stabilize her position by bracing her left leg against the litter. RB reported that the buckle straps across his legs and hips held him well in proper position. RB was able to hold his arm in the proper position for insertion, and the padding on the side of the litter prevented any discomfort.

#### *Parabolas 21-40*

#### *Removal of catheter*

The pump was placed on standby, and the clamp closed on the tubing. DK

removed all of the tape except the last strip over the catheter. DK then placed a 2x2 on the insertion site with her left hand. As the catheter was slid out of the vein by DK with her right hand, the 2x2 was placed over the site with pressure by DK with her left hand. There was no blood loss, and no fluid leakage from the catheter.

*Dressing placement*

A small pressure dressing was placed over the site in RB's left forearm.

*Repositioning of CMO and patient*

RB was then released from the litter while an alteration of CMOs and supplies was performed. Wet and sharp trash was disposed of properly. The IV pump was turned off. During this period there was an unplanned change in sequencing of parabolas which allowed ample time for exchange of CMOs.

PB assumed the role of CMO, and RB repositioned himself in the litter to allow access to his right arm. Due to the difficulty with priming the bag and tubing, it was agreed upon by the group that the same IV administration set and bag would be used for the second attempt.

*Preparation of site and supplies*

The same procedure as above was followed for preparation of the insertion site for the second attempt.

*Insertion of catheter*

A different catheter was used for the second attempt. A #18 gauge catheter with needle/guidewire was used. This type of catheter protects the CMO from any contact with the patient's body fluids.

Again there was no difficulty in insertion of the catheter. A rapid blood return was noted into the tubing of the catheter, and the guidewire was removed.

*Connection to system*

The fluid port was connected to the system, and the fluid bag squeezed to initiate fluid passage. There was no difficulty in administration of the fluid.

*Securing of catheter*

The catheter was secured following standard medical procedures.

*Evaluation of system*

The IV pump was not used on this attempt due to mechanical difficulty. The instillation of fluids occurred easily with pressure placement upon the fluid bag. No difficulties were noted with the administration of fluids through the tubing, catheter and into the vein.

*Removal of catheter*

PB placed a 2x2 over the insertion site and removed the catheter as done in the previous attempt. No loss of fluids was noted.

*Dressing placement*

A small pressure dressing was placed over the insertion site by PB.

*Repeat of previous procedures as required for further evaluation*

Multiple attempts were made throughout the remainder of the flight by all experimenters to have the IV pump function. No success was achieved. It was decided that this would be discussed post-flight with the subsystem engineer.

*Stowage of supplies and equipment*

The waste (all types) was disposed of appropriately. All supplies were replaced within their containers. The ALS pack was closed, and the IV pump turned off.

**RESULTS AND OBSERVATIONS:**

**Photography:**

*Stills:*

Still photography of this flight provided numerous photos, however numerous of them are from too distant a viewpoint to provide adequate resolution of the IV access area.

*S90-36478*

The HMf miniracks with our stowed equipment. The drawers are interchangeable, and those in place for this flight contain the equipment and supplies we need for the IV flight.

*S90-36466*

Photo of the setting for the IV insertion. The litter is secured to the floor of the aircraft with padding for comfort of the patient, and the IV pump is secured to the floor adjacent to the head of the litter. DK is performing a preflight check of the pump prior to the start of the experiment.

*S90-36547*

DK is preparing the IV fluid and tubing for insertion. DK is restrained by bungee cords across her ankles. The IV pump is secured by bungee cords and floor holds. In the background is the transport pack with the equipment required for the flight restrained by bungee cords.

*S90-36546*

DK is attempting to insert the IV tubing into the fluid bag. Note the velcro on the IV bag to allow ease of securing the bag to the side of the IV pump. The tubing is free floating, and frequently got in the way. Management of the various cap covers was difficult.

*S90-36545*

DK is preparing to spike the fluid bag with the IV tubing.

*S90-36539*

DK is flushing the tubing with IV fluid prior to placement on the pump. The IV bag is squeezed to push the fluid through the tubing in zero gravity. RB is in the foreground.

*S90-36491*

RB is secured into the stokes litter. DK is placing the tourniquet on his left arm. PB is in position on the left of the photo for video of the experiment. PB is held in place by bungee cords over his ankles, as is DK. JB is watching from in front of the mini racks. The trash container (fish trap) for the flight is in the right side of the photo.

*S90-37536*

RB is secured into the stokes litter. His left arm has been prepared for insertion and the tourniquet is in place. DK is opening the package of the catheter.

**S90-36535**

DK is inserting the 18 guage catheter in RB.

**S90-36534**

DK has inserted the catheter into the vein and is threading the catheter into position. Note the blood return is visible in the catheter hub.

**S90-36533**

DK is holding RB's hand steady. The catheter is in position with the needle remaining in the hub as the tubing is prepared for connection. The tourniquet has been released. DK is removing the tip cover from the tubing to connect it to the catheter.

**S90-36532**

DK is securing the catheter in place with tape as RB looks on. (poor camera position). The tubing has been connected to the catheter.

**S90-36487**

DK has inserted the catheter and is completing securing the tubing into place. Betadine ointment was placed over the site and covered with a band aid and tape. Transpore tape was used to enable veiwing of the site.

**S90-36530**

PB is attempting insertion of the catheter in RB right hand. DK is preparing the pump.

**S90-36531**

PB is threading the catheter into position.

**S90-36529**

PB is connecting the IV tubing to the catheter tubing.

**S90-36528**

PB has released the tourniquet. The catheter butterfly is taped into place. The remainder of the tubing is free floating.

**Video:**

NASA master reference #117806. Video was reveiwd by the experimenters. The quality of the film was good. Observations derived from the video are included with discussion in this report.

## CONCLUSIONS:

The placement of an intravenous catheter in microgravity is easily accomplished by someone who is well trained and current in the skill. The procedure is a representative task of one very likely to occur on the space station, and would be easily utilized for microgravity training for the CMO prior to duty on the space station. It will give the crew a good perspective of integration of procedures in zero gravity, and can be easily accomplished with the restraints imposed by parabolic flight. It utilizes the understanding and techniques required for CMO restraint, equipment access and utilization, supply management, waste disposal, fluid containment, trouble shooting, human-machine interface, and patient positioning.

1. Determine the difficulties associated with venipuncture in a zero-gravity environment.

The proper placement and restraint of the CMO and patient for this procedure are essential for successful completion of the skill. If these are provided, the skill itself is dependent upon the CMO's capabilities for performance. The technical performance of the insertion of the catheter is not different than in one gravity. Due to the microgravity environment, it requires that the CMO be very organized, and maintain all possible supplies required within easy reach. The venipuncture itself is highly dependent upon the current technical skill of the CMO for successful completion.

2. Evaluate the various methods of securing an IV catheter and attached tubing for infusion with regard to the unique environment.

There appeared to be no unique method required for securing the catheter and tubing in microgravity. The techniques used for securing the IV which are used prior to terrestrial based transport are appropriate for use in the microgravity environment. The tubing floats free where not restrained, but unless there is an area of which it should not enter, or the patient will be moving around a great deal, this should not be a problem. If there is a possibility of the tubing becoming entangled in another piece of equipment, or becoming dislodged; the tubing should have extra tape placed for security. If preferred a gauze roll could be placed on the arm to hold extra tubing in place.

We also felt that placement of velcro on the IV fluid bag worked very well for securing the fluid in place.

3. **Evaluate the various materials available for securing an intravenous catheter in place.**

We recommend the use of transpore tape. This tape is easily torn to the preferred size and shape for application and it is transparent. It also is easily removed, but has appropriate sticking ability.

4. **Evaluate the fluid therapy administration system when functioning in a complete system.**

The two major difficulties with the flight were: 1) the difficulty in priming the fluid administration set with the fluid bag, and 2) the mechanical problem of the IV pump on the second insertion attempt. Other than those two occurrences, the flight went very well. The system works well from end to end. After insertion of the catheter, the pump functioned well with installation of fluid during various movements of the patients extremity. There were no problems. The pump was easy to set up and activate. The fluid administration set was simple to use and install into the pump. Both IV catheters functioned well. Preference of the CMO appeared to be the only difference in use. The guidewire catheter did appear to contain all fluids well. The angiocatheter did not contain the drainage of fluids, the technique of the CMO prevented the fluid drainage.

#### RECOMMENDATIONS:

1. There must be a method for collection and management of the numerous small tip/cap covers on the various ends of tubing and fluid bags. This should be incorporated into any future flights which deal with fluid administration. Possible areas of investigation are use of double stick tape or a foam block with slits.
2. It is recommended that all future filming of a flight have a brief introduction by the PI prior to the flight. This sets the tone for the video and explains what will occur throughout the video. It aids the viewer in understanding the content of the flight, and alleviates the need for a script or worksheet to follow the purpose of the actions which are occurring.



3. The tubing for the administration set floated very freely, and if this had been a sterile procedure would have contaminated the area. A method for control of the tubing should be pursued.
4. There should be a method of securing the fluid bags to the pump. Velcro placed on the exterior of the fluid bags and on the side of the IV pump worked very well.
5. The fluid bag was difficult to purge, and this should be investigated further to discover the cause. This should be designed out of all bags for use at the HMF.
6. The venipuncture itself was no different than a venipuncture in one gravity.
7. One important factor in assurance of success of the venipuncture is the stable restraint of the CMO and the patient.
8. Use of an extension set at the catheter site would facilitate exchange of various tubing sets.
9. Turn the IV pump off prior to removal of the catheter. The surface tension of the fluid in the line will prevent fluid drainage or escape.
10. The pump failure on the second insertion attempt was later discovered to be related to placement of the pump on the floor of the aircraft, and pressure against the audio switch. This feature placement on the posterior of the pump should be removed from the design. A similar situation could easily occur on space station. All switches and buttons should be on the front, and should be protected from accidental activation.
11. The access to the numerous small items required for venipuncture preparation requires the appropriate packaging and collection of contents. This should be investigated with one-gravity simulations to determine the exact content of such a collection. The collection will have to be placed within easy reach of the CMO. A method to assure this access should also be determined. We were able to velcro the start kit to the pump, and had pre-taped all of its contents inside in the appropriate order of use. This should be followed upon for future flights.

12. The guidewire catheter functioned very well for intravenous access, and offers the added assurance of fluid containment. It should be considered strongly for use at the HMF.
13. Training of the CMO for this skill can be accomplished easily in one-gravity. However, this is an ideal skill for instruction in microgravity which integrates numerous concerns for restraint, supply access, waste management of all types (wet, dry, and sharp), fluid containment, equipment activation, and patient positioning.